OPI DATE 11/02/93 APPLN. ID 22419/92
AOJP DATE 08/04/93 PCT NUMBER PCT/AU92/00325

AU9222419

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT [illegible]T)

(51) International Patent Classification 5 :
B65D 65/40, 81/26

A1

(11) International Publication Number: WO 93/01101

(43) International Publication Date: 21 January 1993 (21.01.93)

(21) International Application Number: PCT/AU92/00325

(22) International Filing Date: 2 July 1992 (02.07.92)

(30) Priority data:
PK 7096 5 July 1991 (05.07.91) AU

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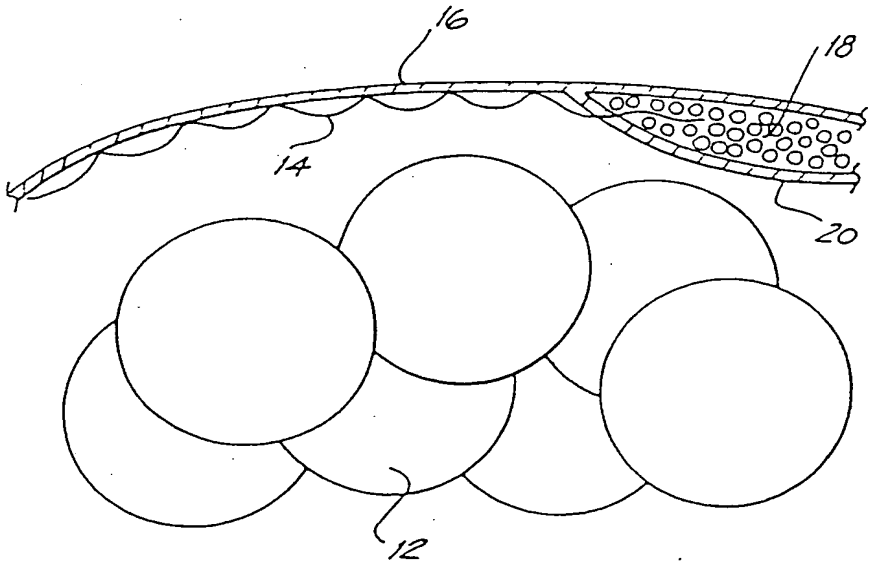
(81) Designated States: AU, CA, JP, US, European patent (AT, BE, CH, DE, DK, ES, FR, GB, GR, IT, LU, MC, NL, SE).

Published
With international search report.

(54) Title: CONTROL OF CONDENSATION



(57) Abstract

The present invention provides a packaging material and method for the control of condensation within packages of horticultural produce and other packages of products requiring high relative humidities. The packaging material comprises a sheet (10) which is impermeable to water in which a first side of the sheet is hydrophilic and is provided with fibres (14) capable of conducting water by capillary action. In preferred forms of the invention the fibres are brought into contact with a desiccant (18) or passed through the sheet material (10).

CONTROL OF CONDENSATION

Field of the Invention

The present invention relates to a packaging material and method for the control of condensation within packages of horticultural produce and other packages of other products requiring high relative humidities. The packaging material and method of the present invention provide a means by which condensed water is transferred to the outside of the package or into a sachet of desiccant without substantially depleting the water vapour content of the atmosphere within the package.

Background of the Present Invention

1. The causes of condensation in packages requiring high relative humidities.

Much of the freshness of horticultural produce, such as fruit, flowers and vegetables can be maintained by packaging it in polymer films. This keeps the relative humidity of the air in the package high, typically at 98% or more of saturation. However, at a relative humidity of 98%, free water will condense where the temperature of any part of the package is about $0.2^{o}C$ degrees lower than the produce. In practice, it is difficult to avoid temperature gradients of this magnitude, either because of small fluctuations in the temperature of storage or because of inadequate cooling of the produce before packing. Even when produce is adequately cooled and temperature control is ideal condensation may occur. This is because the produce itself produces heat in proportion to its rate of respiration. Under equilibrium conditions, the produce will therefore be at a higher temperature than its surroundings. If the resulting temperature difference exceeds the difference between the produce temperature and the dew point, condensation will occur.

2. Harmful effects of condensation

Condensation is harmful when it comes into contact

with horticultural produce. Oxygen diffuses at a much slower rate through liquids than through gases. As a consequence, a film of condensed water on some part of the surface of horticultural produce can impede the supply of oxygen to that part. This may cause a physiological stress to the produce, particularly if the surrounding atmosphere contains much less than the atmospheric level of oxygen, as is the case in modified atmosphere packaging. Solutes such as sugars and amino acids leak from the plant tissue into the condensate, especially where microscopic wounds are present. Such solutes stimulate microorganisms to grow. The microorganisms further reduce the level of oxygen available to the horticultural produce. The overall effect of the condensation is to lower the resistance of the produce to invasion by pathogenic microorganisms.

3. Previous methods used to control condensation.

The most effective method currently used to control condensation in horticultural packaging aims at cooling the produce before packing. Then as long as the produce is never warmer than the package walls are, the dew point will not be reached and no water will condense. Unfortunately this ideal condition is often difficult to achieve in practice.

A second method of control involves attempting to stop condensation occurring by making the packaging material so permeable to water vapour that it is more readily lost to the exterior. This is done by perforating the packaging with small holes. A problem is that this leads to reduced humidities within the package and increased weight loss from the commodity. This method is not compatible with modified atmospheric storage of commodities, because the holes in the packaging allow free diffusion of oxygen in from the atmosphere. It does not work if the atmosphere of the storage room is very humid.

A third method is to place desiccants in the horticultural package within sachets that are freely permeable to water vapour. A problem is that the differences in partial pressure for water vapour between the desiccant and other parts of the bag are small. This results in the transfer of water being diffusion limited and water is preferentially removed from the produce closest to the sachet. The local dehydration reduces the life and quality of the produce.

In contrast with the methods outlined above, the present invention allows condensation to be removed from packages without dehydrating the produce and without decreasing the relative humidity around the produce.

Summary of the Invention

In a first aspect the present invention consists in a packaging material for use in packing produce, the packaging material comprising a sheet which is impermeable to water characterised in that a first side of the sheet is hydrophilic and is provided with fibres capable of conducting water by capillary action.

In a second aspect the present invention consists in a method of packing produce comprising wrapping the produce in a sheet, characterised in that a first side of the sheet is hydrophilic and is provided with fibres capable of conducting water by capillary action.

In a preferred embodiment of the present invention the fibres pass through the sheet material.

In another preferred embodiment of the present invention a desiccant is provided within the package and the fibres are bought into contact with the desiccant.

The fibres may be composed of any of a number of materials provided that they are capable of conducting water by capillary action. Examples include cotton thread and the like, highly hydrophilic super absorbent polyemrs and polymers the sulphate of whichis highly hydrophilic.

A variety of desiccants may be used in the present invention. Any compound that is able to reduce the relative humidity of an environment below 98% can be used. Typical desiccants of this kind are ones made from minerals that absorb water such as silica gel, or salts such as sodium chloride. Organic materials that absorb water such as sugars and other polyhydroxy compounds can be used. Polymeric materials, such as water swellable gels and polyvinyl alcohol may also be used. The common feature of suitable desiccants is that they should be able to provide local environments with a relative humidity lower than 98%.

In the embodiment where a desiccant is provided and there is no perforation of the sheet by the fibres, the packaging material and method of packaging of the present invention may be used in modified atmosphere packages.

Detailed Description of the Invention

In order that the nature of the present invention may be more clearly understood, preferred forms thereof will now be described with reference to some of the accompanying drawings:-

Figures 1, 2 and 3 show the set up and results of experiments to demonstrate the theory behind the present invention.

Figures 4, 5 and 6 show various embodiments of the present invention.

In Fig. 1A a glass bottle is shown that contains liquid water. The lid of the bottle is pierced by a hole of diameter 1mm. In Fig. B the weight of water lost through the hole to the atmosphere (relative humidity 55%, temperature 21^{o}C) is plotted as a graph against time over 25 minutes. The result indicates that the loss of water as vapour through the hole was too small to be measured over the time scale used.

Fig. 2A shows a similar set up except that a cotton

sewing thread has been passed from the liquid reservoir through the hole so that liquid water may be transferred to the outside by capillary action and be evaporated there. Fig. 2B shows the plot of weight water lost. In this case, there was a constant rate of water loss through the cotton capillary of about 0.8 micrograms per minute.

The principles demonstrated by Figs. 1 and 2 are used in the invention described below. A material capable of conducting water by capillary action is used to transfer condensed water from a region in equilibrium with a high relative humidity of the gas phase or high water potential, to a region in equilibrium with a lower relative humidity of the gas phase, or lower water potential.

The setup in Fig. 3 is similar except that the contact of the cotton thread with the water reservoir has been broken. The graph shows that this stops the transfer of water.

The results of Figs. 1 to 3 illustrate how capillary flow along a wick can transfer water only when it is in contact with liquid water. This principle is used in the invention described below.

One configuration of the invention is shown in Fig. 4. A package is made of a material 10 that restricts water loss from the horticultural produce 12. The inner surface of the packaging material 10 is hydrophilic. That is, water in contact with the inner surface will spread and not form discrete droplets. In addition, the inner surface of the packaging material is contacted by or laminated with fibres or threads 14 capable of conducting water by capillary action. An example of such a material is cotton thread. The material conducting water passes at a point or at several points through the packaging material 10, to be exposed on its outer surface. In this configuration of the invention, the average relative

humidity outside the package is assumed to be substantially less than 98%, as is typical of refrigerated stores. Under these conditions, any condensation on the inner surface of the package spreads and is absorbed by cotton thread 14. It is transferred by capillary action to the outside of the package which is at a lower water potential and where it evaporates. Once the condensate has been totally removed in this way, there is no further transfer of liquid water. Net transfer of water will be reduced to that through the gas phase. The rate at which this occurs is small and the produce is therefore not desiccated.

Fig. 5 shows a second configuration of the invention which is suitable for use in modified atmosphere packages. A package is made of a material 16 that restricts the transfer of oxygen, carbon dioxide and water to and from the atmosphere surrounding horticultural produce 12. The inner surface of the material 16 is hydrophilic and is contacted by or laminated with fibres or threads 14 that are capable of conducting water by capillary action. A desiccant 18 is contained in a water-impermeable sachet or pouch 20. The cotton thread 14 that contacts the inner surface of the packaging material passes through the wall of the desiccant sachet or pouch 20. Any condensate is conducted along the fibres or threads 14 to the desiccant 18 where it evaporates. When horticultural produce 12 is placed within the package it can be sealed hermetically to form a modified atmosphere package. In this case, the permeation of oxygen into the package is balanced by the respiratory use of oxygen by the horticultural produce. This balance is achieved at some reduced level of oxygen typically between 1 and 10%. In an analogous way, the level of carbon dioxide within the package is elevated, typically between 1 and 15%. This is achieved by the rate of respiratory

production of carbon dioxide being equal to the rate of permeation of the carbon dioxide out of the package. A substantial barrier to the permeation of gases is necessary for modified atmosphere packaging to work. This means that holes to allow the exit of any condensation water must not be present. This requirement is met by this configuration of the invention, as the water is removed by a desiccant within the package. Because the desiccant is contained within a package impermeable to water it does not dry out the produce.

Another configuration of the invention is shown in Fig. 6. It takes the form of a condensation control flake, in which a desiccant 22 is sealed within two leaves of water impermeable polymer 24. Fibres or threads 26 are capable of transferring water by capillary action traverse the walls of impermeable polymer 24. Flakes made in this way may be scattered in packages where condensed water is likely to accumulate. The flakes will absorb any liquid water that they contact, but will not appreciably lower levels of relative humidity.

As can be seen from the above the packaging material and method of the present invention provide a means by which produce may be packaged without dehydration of the produce. The packaging material and method of packaging of the present invention also substantially ameliorates the problem with the prior art of water condensing on the surface of the horticultural produce.

It will be appreciated by persons skilled in the art that numerous variations and/or modifications may be made to the invention as shown in the specific embodiments without departing from the spirit or scope of the invention as broadly described. The present embodiments are, therefore, to be considered in all respects as illustrative and not restrictive.

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CLAIMS:-

1. A packaging material for use in packing produce, the packaging material comprising a sheet which is impermeable to water in which a first side of the sheet is hydrophilic and is provided with fibres capable of conducting water by capillary action, wherein the fibres either pass through the sheet material or are brought into contact with a desiccant provided within the package.

2. A packaging material as claimed in claim 1 in which the fibres are cotton threads.

3. A method of packing produce comprising wrapping the produce in a sheet in which a first side of the sheet is hydrophilic and is provided with fibres capable of conducting water by capillary action, wherein the fibres either pass through the sheet material or are brought into contact with a desiccant provided within the package.

4. A method as claimed in claim 3 in which the fibres are cotton threads.

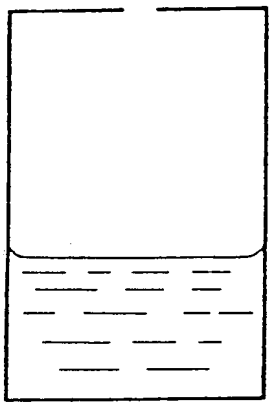

FIG. 1A

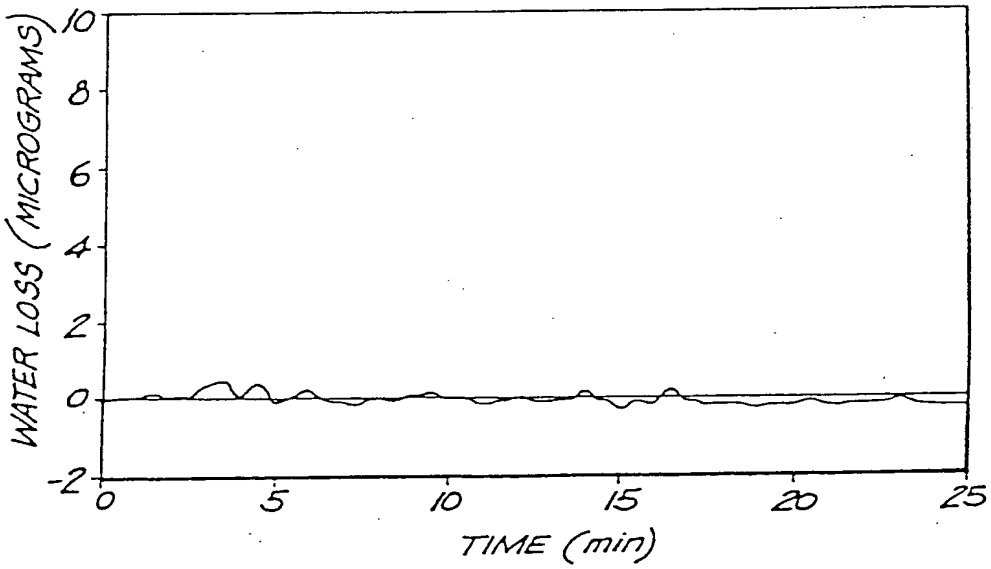

FIG. 1B

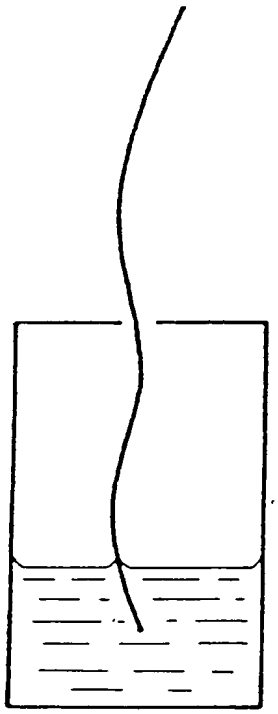

FIG. 2A

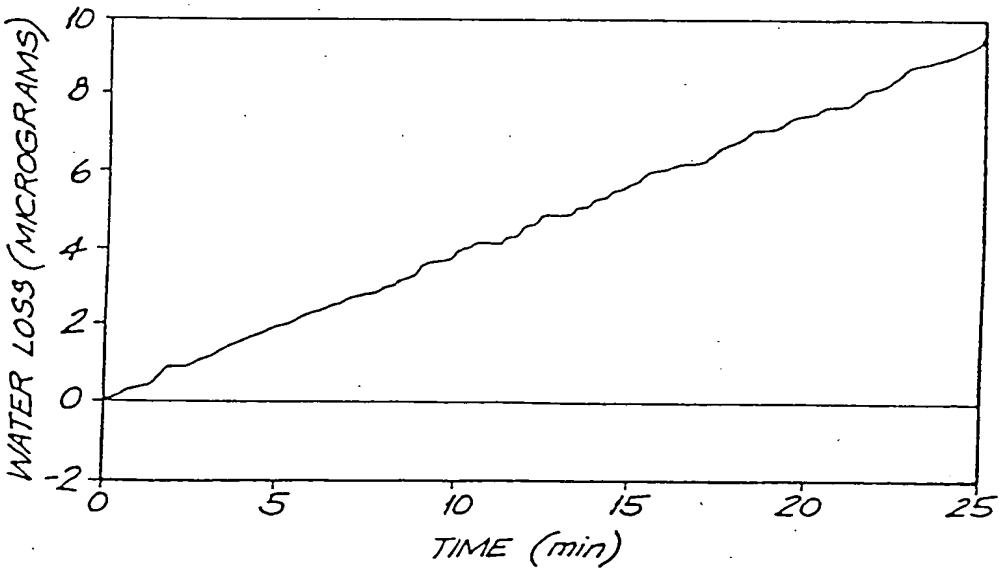

FIG. 2B

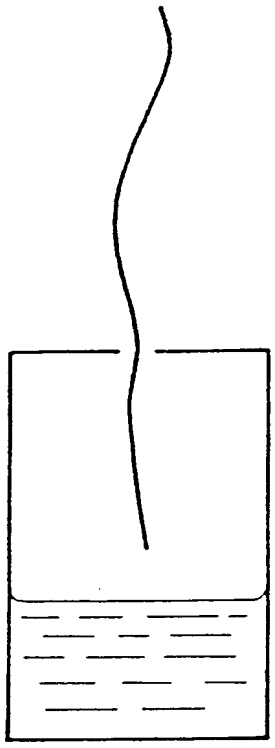

FIG. 3A

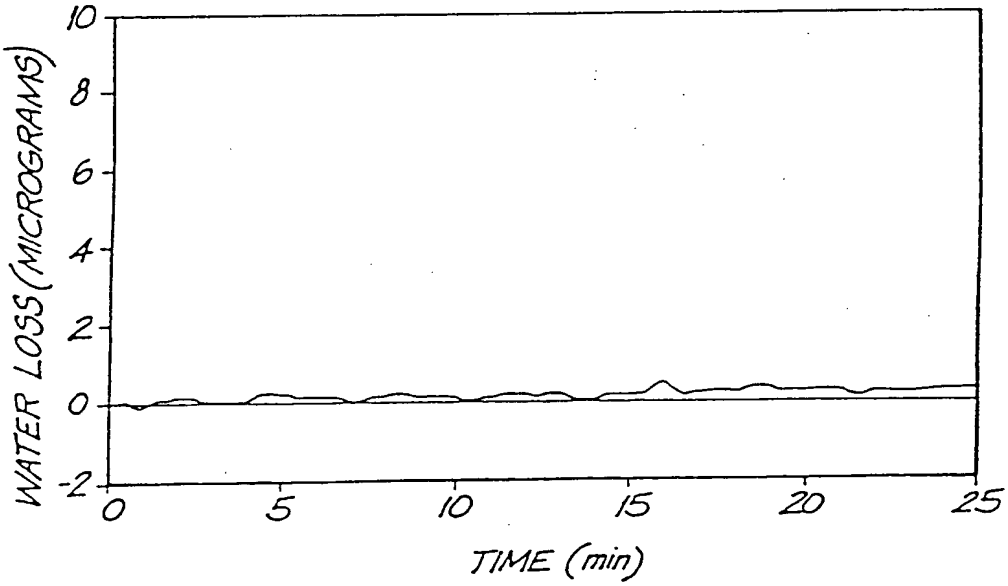

FIG. 3B

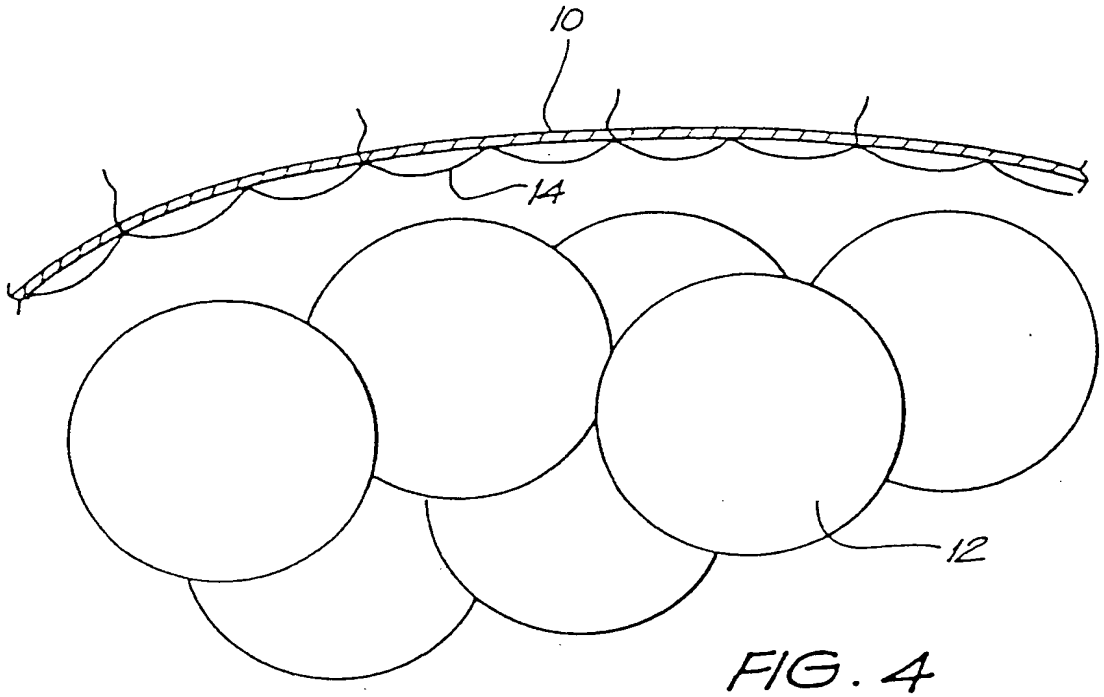

FIG. 4

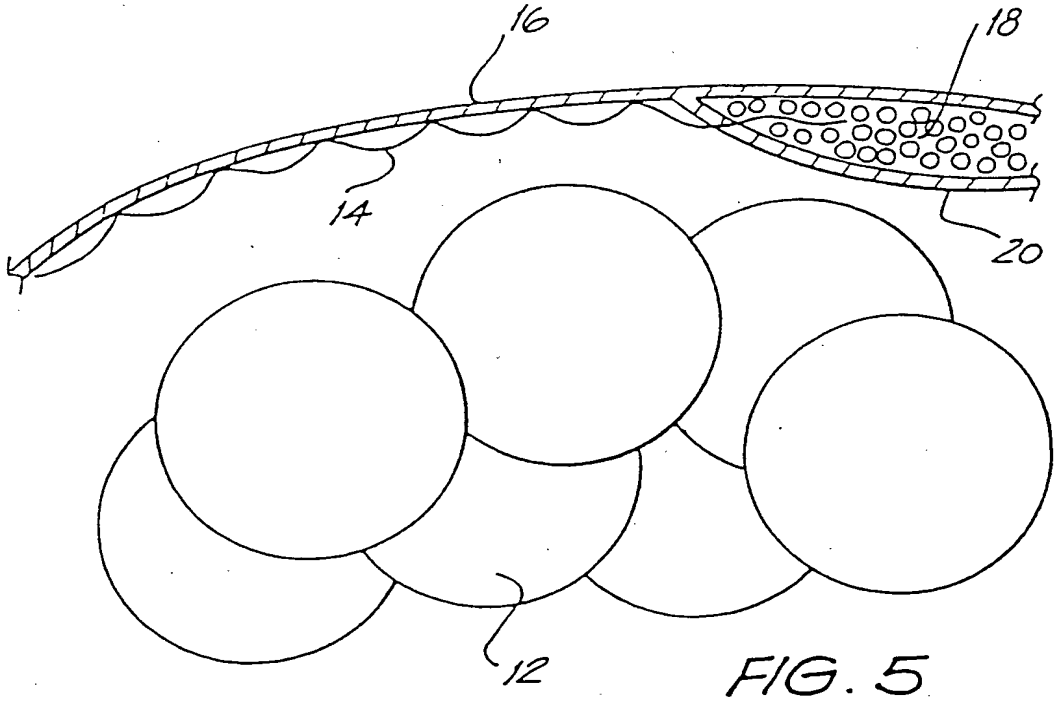

FIG. 5

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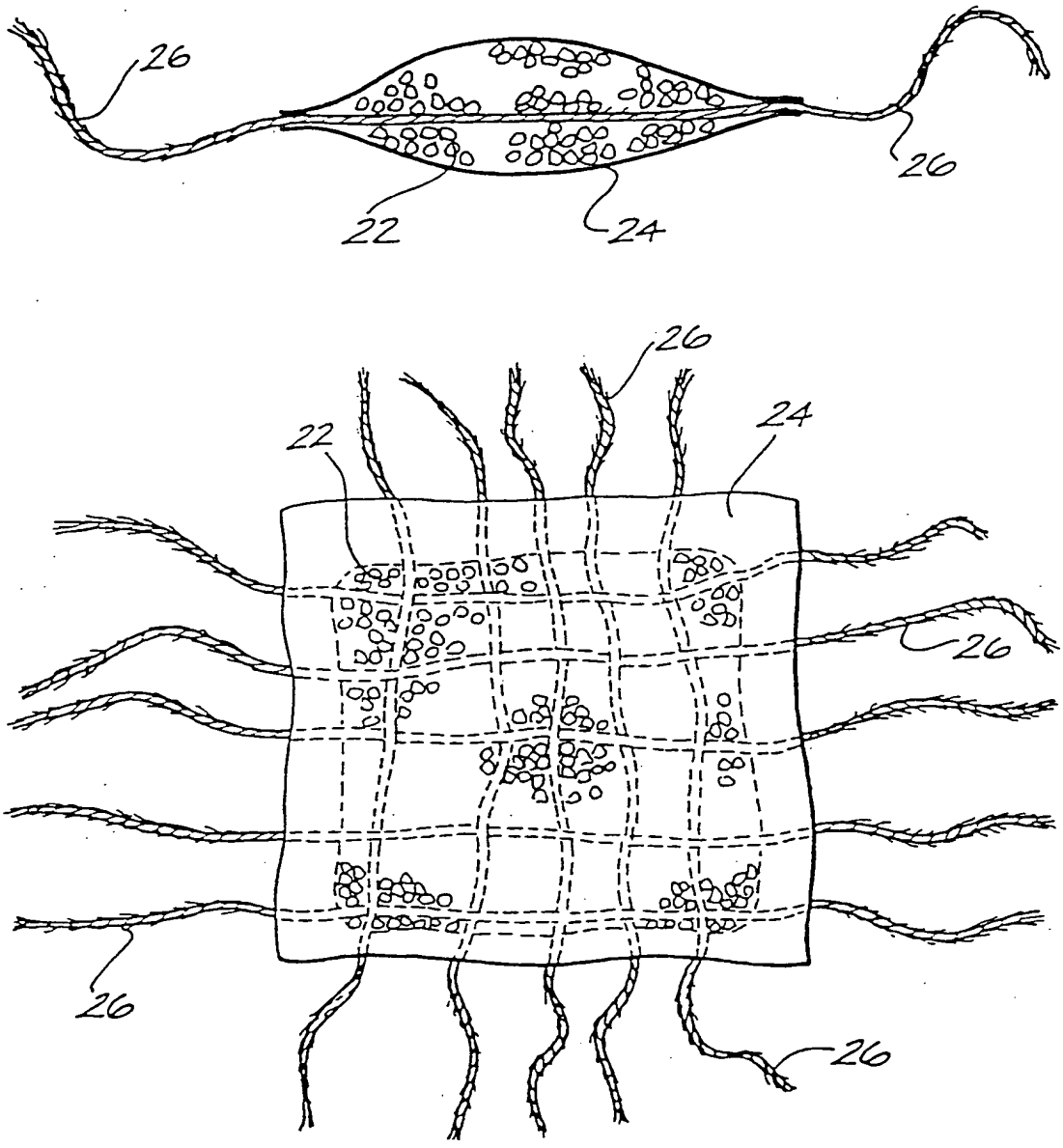

FIG. 6

INTERNATIONAL SEARCH REPORT

International applicati/
PCT/AU92/00325

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl[5]. B65D 65/40, 81/26.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC B65D 65/40, 81/26

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU: IPC as above + A01G 27/00 (AU only).

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT: B32B and Hydrophillic
JAPIO: B32B and Hydrophillic

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	AU, A, 36774/89 (KIMBERLY-CLARK CORPORATION) 4 January 1990 (04.01.90). page 6 lines 9-24, fig. 3	1, 5
X	AU, A, 59553/80 (DOW CHEMICAL Co., The) 15 January 1981 (15.01.81) claims 1-7	1, 5
X	AU, B, 37844/63 (270801) (BANCROFT PAPER COMPANY INC.) 20 May 1965 (20.05.65) claims 1-7	1, 5

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
26 AUGUST 1992 (26.08.92)	8 SEP 1992 (08.09.92)

Name and mailing address of the ISA/	Authorized officer
AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA	G M COX
Facsimile No. 06 2811841	Telephone No. (06) 2832484

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim No.
X	AU, B, 1131/51 (149502) (AMERICAN VISCOE CORPORATION) 3 May 1951 (03.05.51) whole document.	1, 2, 4-6, 8
Y	AU, B, 71964/81 (517178) (SYLVESTER O.) 1 October 1981 (01.10.81) claim 1.	1, 2, 4-6, 8
Y	AU, A, 27530/77 (COLGATE-PALMOLIVE CO.) 8 February 1979 (08.02.79) claim 1.	1, 5
Y	AU, A, 18620/76 (IMPERIAL CHEMICAL INDUSTRIES LIMITED) 20 April 1978 (20.04.78) claims 1-11.	1, 5
Y	AU, A, 61006/69 (INTERIOR GARDENS LIMITED) 25 March 1971 (25.03.71) page 2 line 1 to page 3 line 7; Fig. 1.	1, 2, 5, 6
Y	Patent Abstract of Japan, M 950, page 90, JP, A, 2-8048 (EIWA KAGAKU KOGYO K.K.) 11 January 1990 (11.01.90) Abstract.	3, 7

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member						
AU	36774/89	EP	348840	JP	2109879	US	4997082
		ES	2016701				
AU	59553/80	AT	9558	BR	8004223	CA	1127059
		DK	2944/80	EP	22227	FI	802168
		JP	56015348	JP	61034389	NO	802057
		US	4293609				
AU	74964/81						
AU	27530/77	BE	857878	BR	7705514	CA	1124004
		CH	617329	DE	2736820	DK	3494/77
		ES	238923	FR	2361834	GB	1560432
		IE	45563	IT	1079841	JP	53025144
		MX	148504	MY	163/83	NL	7708776
		PH	14875	PT	66904	US	4050463
		ZA	7704617				
AU	18620/76						
AU	61006/69	BE	739116	DE	1947661	ES	371670
		FR	2018539	GB	1292802	IL	33021
JP	2008048						

END OF ANNEX